(*Axiom* 2). The acceleration of a given piece of matter is proportional to the (effective or resultant or unbalanced) force acting on it, and is in the same direction.

(*Experience* 4). Stresses in a body do not accelerate it as a whole.

(*Axiom* 3). The two forces of a stress are always balanced.

[*Or otherwise* (after Experience 3).]

(*Definition* 2). The ratio of the force acting to the acceleration produced in a given piece of matter is called its "inertia."

(*Axiom a*). The inertia of a given piece of matter is unconditionally constant, and has no direction.

(*Remark*). Inertia is therefore taken as the most fundamental property of matter, and is used to measure its massiveness or "mass."

Definition 3). The centre of mass of a system is a point such that $\Sigma(mr) = 0$; *or*, it is a point moving with speed v, such that $\Sigma(m)\mathrm{v} = \Sigma(m\mathrm{v})$.

(*Axiom b*). The centre of mass of a system is not accelerated by internal stresses, but only by one component of a stress whose other component acts on a body foreign to the system.

(*Deduction*). The two forces of a stress are always equal and opposite.

(*Remark*). A brief and convenient statement of Axiom 2, by help of Definitions 1 and 2, is $F\,dt = m\,d\mathrm{v}$. Note that F and $d\mathrm{v}$ have necessarily the same sign; they are parallel vectors.

(*Experience* 5). Every force is one component of a stress; in other words, bodies can only mechanically act on one another (*i.e.* so as to affect each other's motion) by means of stress; or stress is essential to mechanical action.

(*Remark*). This might have been made part of Axiom 3, but it is really a distinct statement. Perhaps it should be stated as an axiom.

(*Axiom* 4). A stress cannot exist in or across empty space.

(*Deduction*). Therefore bodies (or any media) immediately acting on each other are necessarily in contact, and stress exists at the point of contact, where the normal components of their velocities (v) are identical.

(*Experience* 6). When stress and motion coexist, action occurs or activity is manifested.

(*Definition* 4). The scalar product of the two vectors $F\mathrm{v}$ is called "activity."

(*Deduction*). The activities of two immediately acting bodies are equal and opposite.

(*Remark*). Elastic bodies under stress, and moving bodies with inertia, are found to be able to manifest activity, and are said to possess energy whereby they can do work on other bodies. Stress energy is called potential; motion energy is called kinetic.

(*Definition* 5). Work done $= \int(\text{activity})\,dt =$ energy gained or lost.

(*Remark*). There are two ways of regarding this quantity: $\int Fv\,dt$; namely either as $F(v\,dt) = F\,ds =$ change of potential energy, or as $v(F\,dt) = v.m\,d\mathrm{v} =$ change of kinetic energy.

A body for which Fv is positive is losing energy; a body for which Fv is negative is gaining energy.

(*Deduction*). Since the activities of two immediately acting bodies are equal and opposite it follows by Definition 5 that energy lost by one is gained by the other; *i.e.*, that energy is simply transferred without loss or gain across the point of contact in the direction of the common velocity.

(*Axiom* 5). Energy which is not being actively transferred from one body to another remains unaltered in quantity and form.

(*Remark*). Energy which is being transferred from one body to another changes its form. The kind of transformation depends on the sign of dv with respect to the common velocity of the acting bodies at their point of contact.

If $v\,dv$ is positive, energy is being transformed into kinetic; if $v\,dv$ is negative, it is being transformed into potential; if $v\,dv$ is zero, there is a mere flux or transmission of energy without transformation.

(*Deduction*). Since transference of energy is essential to activity it follows that only bodies which are able automatically to part with some of their energy, are able automatically to do work. In other words, automatically transferable energy is alone available or potential.

(*Experience* 7). The automatically transferable or potential energy of a body or system is liable to transfer and transform itself into kinetic. Hence

(*Axiom* 6). The potential energy of a system tends towards zero.

(*Experience*). Kinetic energy is only available when associated with appreciable or relative momentum.

The following statements may be made about the irregular and aggregate motion of particles called Heat.

(*Experience*). Heat will not flow from low to high temperature by mere conduction (as it could, for a time, if it possessed inertia, like water, air, or electricity). It can only flow from cold to hot by help of convection by matter or something else. Such flow is therefore not a cyclical or perennial process.

(*Deduction*). Energy of average temperature is useless for continuous work. In other words, the only available or potential portion of heat-energy, when dealt with in the aggregate, is that which a body is able freely to emit to colder bodies.

(*Definition*). The absolute temperature of a body is to its total heat-energy as the available fall of temperature is to its potential heat-energy.

OLIVER LODGE.

THE ROYAL SOCIETY SOIRÉE.

THE Royal Society Soirée on May 10 was in every way most successful. It was very numerously attended, and much interest was excited by many of the exhibits and by the demonstrations. In the following account of the exhibits we give a full account only of such objects as have not before been referred to in NATURE:—

Captain Abney, C.B., F.R.S., and General Festing, F.R.S., exhibited experiments on the extinction of light and colour.

Sir J. B. Lawes, Bart., F.R.S., and Dr. J. H. Gilbert, F.R.S, exhibited a series of photographs relating to the working of the Rothamsted Laboratory. In experiments on the growth of root-crops year after year on the same land, it was found that after a very few years of growth without manure, the root no longer developed the swollen character of the cultivated plant, but remain fusiform as in the uncultivated condition. The photographs strikingly show the same characters in roots grown in rotation without manure; also that mineral manures alone greatly favour the development of the swollen root, but that mineral and nitrogenous manures together do so in a much greater degree. The results further show how artificial a product is the cultivated root-crop, and how dependent it is on an abundant supply of food within the soil—nitrogenous as well as mineral. Indeed, details of the experiments afford conclusive evidence that it is quite fallacious to suppose that root-crops derive a large amount of their nitrogen from atmospheric sources by means of their extended leaf surface.

Three instruments for the study of Crystals were shown by Mr. H. A. Miers. (1) A goniometer by which crystals can be measured under liquids, or during their growth from solution. (2) A stage-goniometer by which small crystals or fragments can be adjusted and rotated under the microscope. It is here fitted to the stage of the petrological microscope designed by Mr. A. Dick. (3) An improved form of polariscope on the plan devised by Prof. W. G. Adams, F.R.S. The hemispheres which enclose the crystal section can in this instrument be accurately centred so that exact measurement of the optic axial angle is possible.

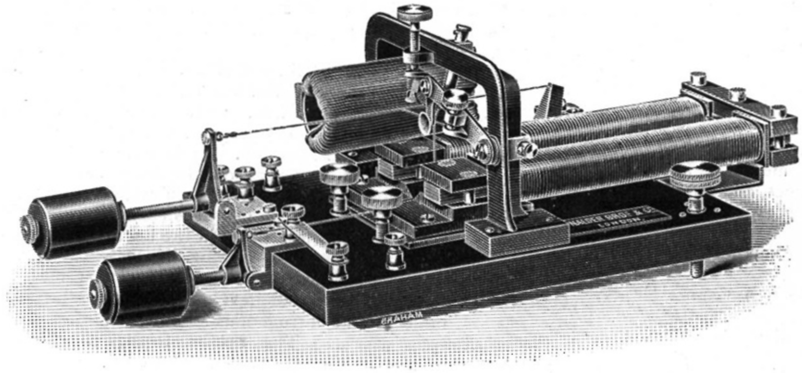
Prof. Rücker, F.R.S., and Prof. Thorpe, F.R.S, exhibited maps showing the forms of the true lines of equal declination, equal horizontul force, and equal dip in the United Kingdom for the epoch, Jan. 1, 1891.

Mr. A. A. C. Swinton exhibited high frequency electric experiments. (1) The filament of an ordinary 5 c.p. 100-volt lamp is caused to incandesce with current conveyed through the human body. (2) Sparks, evidencing a difference of potential of some thousands of volts, produced between the two hands of the same operator. (3) Luminous spiral produced in exhausted glass tube by molecular bombardment from wire spiral wound outside tube. (4) Some effects produced by high frequency discharges passing through semi-conducting substances, and striking liquids.

Sodium potassium high temperature thermometers, and specimens of the alloy, were exhibited by Mr. E. C. C. Baly and Mr. J. C. Chorley. These thermometers are filled with an alloy of sodium and potassium which is liquid at ordinary temperatures. Their range is from 0° to 620°C. (1,150°F.); the softening point of the glass, a specially hard kind, being about 650°C. The separate specimens of the alloy are exhibited to show its purity and its very remarkable surface tension.

Mr. Cecil Carus-Wilson exhibited the scotographoscope, for enabling lecturers to demonstrate with chalk in a darkened room. A compartment encloses a lamp so arranged as to cast a pure white light upon the interior surface of the sheet of specially prepared glass, which forms the front of the apparatus. In a darkened room, on removing the sliding screen, an intensely white surface is exposed, upon which chalks of any colour can be used in the ordinary way. Small chalk drawings easily seen at a distance of 100 feet or more, and they may be rapidly deleted by means of a damp sponge. The whole apparatus folds into a small compass for travelling.

Magnetic curve tracers, were exhibited by Prof. Ewing, F.R.S. The magnetic curve tracer exhibits the relation of magnetism to magnetising force in iron. A mirror, which is free to move both vertically and horizontally, receives two component motions: one (horizontal) proportional to the magnetising force H, and the other (vertical) proportional to the magnetisation B. The reflected light traces the characteristic cuve or B and H, exhibiting the influence of magnetic hysteresis. The instrument at work in the recess shows a cyclic process caused by periodic rapid reversals of magnetising force. A more recent form of the magnetic curve tracer is also shown (made by Messrs. Nalder Brothers) which is arranged for the commercial testing of iron. The metal whose magnetic qualities are to be tested is made up in rods, which are readily inserted and removed. The rods which are shown are built up of narrow strips of sheet iron.



Prof. A. Smithells, B.Sc., exhibited experiments to demonstrate the structure of flames. (1) The separation of a non-luminous coal-gas flame into two combustion cones is effected by sliding a wider tube over the one on which the flame rests. The products of combustion can be aspirated from the intervening space. (2) Using benzene vapour instead of coal-gas, the transition from a simple luminous flame to a non-luminous flame is shown. The two cones of the latter are separated as before, and by a further addition of air the outer cone disappears, the complete combustion occurring in a single cone. (3) By introducing a spray of a solution of a copper salt, it is seen that the coloration of the flame occurs only in the outer cone where copper oxide is formed. (4) The cone flames are also separated by using a single tube. A platinum wire is pushed up axially till it touches the inner cone. On drawing it down, the inner cone is inverted and follows the wire.

Rev. F. J. Smith, M.A., exhibited an inductoscript. The inductoscript figures and pictures are made by placing the object to be reproduced in contact with an ordinary photographic plate, placed upon a conducting sheet of metal. The object and the plate are connected to the terminals of an induction coil or other source of electricity, for a fraction of a second, and then developed in the usual manner. Several of the pictures shown were produced on plates which had been exposed to full daylight. The pictures marked B were produced by the same method on bromide paper. Non-conductors such as wood blocks are coated with a surface of plumbago before being operated on. The best results are obtained by conducting the process in oxygen gas under a pressure of about two atmospheres.

Platinum thermometers and pyrometers, compensated resistance boxes and galvanometers, compensated barometer and air thermometer, exhibited by Mr. H. L. Callendar; a series of sections illustrating the seasonal distribution of temperature in sea-water lochs, exhibited by Dr. Hugh R. Mill; a portable hydrogen oil safety lamp, adapted for illumination and delicate testing in air containing any kind of inflammable gas or vapour, exhibited by Prof. Frank Clowes, D.Sc.; tuning forks worked electrically, a portable photometer, a table polariscope, exhibited by Sir David Salomons; high tension apparatus, exhibited by Sir David Salomons and Mr. L. Pyke; electrical apparatus, exhibited by Major Holden.

The Marine Biological Association exhibited marine invertebrata from the Plymouth area. Selected specimens of crustacea decapoda, and mollusca opisthobranchiata, including many rare species, and illustrating the richness of the Plymouth fauna.

Dr. G. H. Fowler exhibited specimens of oyster shells. The specimens illustrate:—(1) The rate of growth of the oyster. (2) Natural varieties of the shells. (3) Modifications of a variety bred under new conditions.

Prof. Weldon, F.R.S., exhibited diagrams showing the frequency of variations in the size of certain organs of crabs. The diagrams are based on measurements of portions of the carapace and other parts of *Carcinus mœnas*. The organ to which each diagram refers is indicated in the central drawing of a crab. Each diagram is based upon measurements of 1,000 individuals, and the size of the organ measured is indicated (as a percentage of the body length) on the base-line of each. The vertical ordinates of the black curve show the number of individuals having the organ measured of the given magnitude, and the red curve is a probability curve.

Spectra of the flame from a Bessemer converter, exhibited by Prof. W. N. Hartley, F.R.S. The photographs comprise the solar spectrum intended for reference, together with spectra of the Bessemer flame taken at consecutive periods of the "blow" as indicated by the time during which the plate was exposed in each case. The flame spectra will be seen to be composed of (1) a continuous spectrum due to carbon monoxide; (2) a band spectrum belonging to metallic manganese; and (3) a line spectrum principally belonging to iron. Lines of potassium, sodium, and manganese are also present. Taken at the Crewe Works of the London and North-Western Railway Company, by permission of Mr. F. W. Webb, January, 1893. Enlarged ten diameters by the Autotype Company.

Prof. J. Norman Lockyer, F.R.S., exhibited the photographic spectra of some of the brighter stars.

Mr. Isaac Roberts, F.R.S., exhibited five original negatives and enlarged photographs of nebulæ and clusters of stars, taken with the 20-inch reflector by the exhibitor.

Some species of butterflies, illustrating protective mimicry were shown by Colonel Swinhoe. Mimetic forms of the nymphalid genus Hypolimnas in India, Malayana and Africa, showing the various phases of development of mimicry in two widespread species of the same genus; also mimetic resemblances to different protected species in the females of *Euripus halitherses*, &c.

The Zoological Society of London exhibited specimens of lepidopterous insects bred in the insect house of the Zoological Society in London. Four cases containing specimens of *imagines* or perfect insects, raised from *chrysalides* or pupæ in the Zoological Society's insect-house in the season of 1892. They belong chiefly to the silk-producing moths of the family Bombycidæ, and to the diurnal lepidoptera or butterflies.

Remains of extinct birds from New Zealand and the Chatham Islands (off the coast of New Zealand), exhibited by Mr. H. O. Forbes. The exhibit consisted of the chief portions of the skeleton of *Aphanapteryx Hawkinsi* (Forbes), a genus of rails known hitherto only from Mauritius, and of *Palæocorax Moriorum* (Forbes), a large raven, a form not otherwise known in the region; portions of the skeleton of a large *Fulica*, and of a species of swan, now extinct, from the Chatham Islands; a part of the skull of a large Auserine bird allied to *Cereopsis*, found associated with moa remains in a bog in New Zealand; the tibia of a new species of *Cnemiornis*, an extinct giant goose

(*C. gracilis*, Forbes), and the limb bones of three species, belonging to a new genus *Palæocasuarius* (Forbes), of the *Dinornithidæ*.

Dr. D. Sharp, F.R.S. exhibited some ants and their sound producing organs. The sound-producing organs of ants consist of very fine parallel lines engraved on a portion of the outer surface of the chitinous skeleton and of a scraper or very fine edge. Great delicacy of movement may be given to the latter instrument by means of a ball-and-socket joint.

Sections showing the microscopic structure of certain fossil cryptogamic plants from the coal-measures, exhibited by Prof. W. C. Williamson, F.R.S., and Dr. D. H. Scott; white corpuscles of the blood and lymph under the microscope, exhibited by Mr. W. B. Hardy and Dr. A. A. Kanthack; maps and photographs illustrating the Sandgate Landslip, exhibited by Mr. W. Topley, F.R.S., and Mr. R. Kerr, F.G.S.

Mr. Edward Matthey F.C.S. exhibited form in which antimony separates from bismuth at a temperature of 350°C. The specimens are those of the film as removed from the surface of the melted antimonial bismuth. They consist of antimony oxide, containing about ten per cent. of bismuth.

Two compact voltaic batteries of zinc and platinum, were shown by Dr. G. Gore, F.R.S.

Major P. A. MacMahon, F.R.S., exhibited peramutational tesselations. A new method of obtaining designs for tesselated pavements, based upon the property possessed by the twenty-four different isosceles right-angled triangles derived by permuting four designs in all possible ways upon the sides.

Mr. E. Wethered exhibited photo-micrographic lantern slides, illustrating the micro-organisms in limestone rocks. The slides especially illustrate the remarkable structure known as *Girvanella*.

Lord Armstrong, C.B., F.R.S., exhibited experiments to show the nature of the electric discharge in air and water. The experiments will all be exhibited in action on the screen of the electric lantern, and will include the transfer of a cotton string from one vessel to another by means of a current of water flowing within another under the influence of electricity. Various dust figures will also be formed and similarly shown, displaying the nature and effects of the electric discharge in air.

Preparations and photographs demonstrating the action of solar and electric light on the spores of bacteria and fungi, exhibited by Prof. H. Marshall Ward, F.R.S.

THE INTERDEPENDENCE OF ABSTRACT SCIENCE AND ENGINEERING.

ON Thursday evening, May 4, the first "James Forrest" Lecture was delivered at the Institution of Civil Engineers, by Dr. William Anderson, F.R.S. The subject was "the interdependence of abstract science and engineering." After briefly explaining the origin of the lecture, Dr. Anderson proceeded:—The theme which has been prescribed is "The Interdependence of Abstract Science and Engineering," and I imagine that the subject has been chosen because of an uneasy feeling, which possesses many thoughtful men, that this country is not keeping pace with its neighbours in engineering progress, and that we shall, in the future, have to pay more attention to abstract science and its application to practice, than we have been, so far, in the habit of doing.

With rare exceptions, in this country, has there been even a slender amount of theoretical knowledge imparted to various grades of employment; it is only during the last few years that Science Colleges and technical education in schools and People's Palaces, are beginning to bring our operatives up to the level of our foreign friends, but, unfortunately, too late to retain that pre-eminence which we at one time could claim, and, I fear, placed too much confidence in; and moreover, a new danger has arisen in the circumstance that popular scientific education has taken a one-sided direction, that of mechanical and technical knowledge alone, so that, though the operative approaches his work with increased intelligence, he remains unfit to reason out the great economic problems on which his own welfare and that of the nation depend.

It is a matter of extreme surprise to me that so little attention is paid to the science of Political Economy, that not only the mass of the people, in whose hands the voting power now lies, but even, in a great measure, the representatives whom they elect, have no systematic training in, and are grossly ignorant of, the principles which lie at the root of national prosperity. The further misfortune follows that politicians of the highest position do not scruple to trade on this ignorance, or pursue a course which, in its consequences, is as bad—being ignorant themselves they strive to lead the ignorant, and set the operative against his employer and against society in general. The cheapness of newspapers, their wide diffusion, and their blind, not to say reckless advocacy of popular fallacies acting on the ignorance, prejudices, and discomfort, if not suffering, of the operative classes, are giving enormous power to trade organisations, whose avowed object it is to improve the earnings and social standing of the operative at the expense of, or at any rate without regard to, the interests of every other class in the community, and this is to be accomplished not by encouraging education, not by advocating thrift and temperance, not by urging the workman to improve his mechanical dexterity, the thoroughnesss of his work and the amount which he produces, but by holding out visions of shortened hours of labour, by compelling a minimum of pay which will enable him to live in comfort, of systematically restricting the amount of work done by each individual, even in the shortened day, all under the fatal illusion that by such means a greater number of men will find more remunerative employment.

The employer is usually credited, by the trade leaders, with accumulating wealth without effort, risk, or anxiety, by the slavish labour of his operatives, while the proofs to the contrary, so easily to be obtained in the slender dividends declared by most industrial enterprises, and in the records of the Bankruptcy Courts, are steadily kept out of view.

There would be no fault to find with the new class of professional agitators, who live by the discontent which they foment, were they, and the Unions which they manipulate, to contribute in the smallest degree to the obtaining of that work and of those orders, in the execution of which the wage-earning portion of the community have their being. This, the most difficult part of every commercial enterprise, is left to the much-abused capitalist, so that the absurd and impossible system is fast asserting itself, that professional skill, mercantile ability, and capital, shall obtain the work, and run *all* the risk of design, execution, and financial security; but that work shall be carried out according to rules which self constituted and perfectly irresponsible bodies choose to impose. The smallest acquaintance with the principles of political economy would demonstrate that such methods must end in ruin, that they are utterly incompatible with our policy of Free Trade—a system which is perfectly reasonable and proper if thoroughly carried out, and which certainly never contemplated the protection of one particular class, and that, not by edict of the State, but at the bidding of self-constituted tribunals whose claims amount to this:—that there shall be free trade in all products which the operatives require to buy, but the strictest protection as to all that they have to sell, namely their labour, and whose ultimate methods are violence, and the coercion of all who differ from views which many intelligent but timid workmen know to be at variance with the true interests of their class.

Under all this lies the socialistic idea of equality in the condition of every member of the community, an idea which political economy demonstrates to be utterly Utopian and impossible. Since the creation of mankind the differences in social position and in material comfort which follow naturally from the endless variations of mental and bodily powers in men, have existed, and, in spite of many abortive attempts, more or less violent, to establish equality, will exist for ever; for it seems to me that the doctrine of Carnot with respect to heat-engines applies by analogy to the question of national prosperity. To obtain mechanical power from a source of heat there must be a fall of temperature, and the greater that fall is the more efficient will the engine be—a dead level of temperature simply means extinction of energy and of life. To ensure active trade and prosperous manufactures there must be a fall of money or of its equivalent from the wealthy to the comparatively poor, the one class is absolutely essential to the other; the prosperity of the community is bound up in the existence of these differences, and a dead level of wealth would be a dead level of poverty, which would end, as a state of uniform temperature must end, in absolute stagnation and death.

However much we may regret the inequality which exists in the distribution of wealth and comfort, it is just as much a law of nature as the unequal distribution of warmth, of sunshine, or of rain, and seems to me to follow naturally and inevitably